# A multidisciplinary collaborative care model involving family members in the treatment of type 2 diabetes mellitus and associated diabetes distress in young and middle-aged patients

## Multidisciplinarni model nege koji uključuje saradnju porodice u lečenju dijabetesa melitusa tipa 2 i pridruženog dijabetesnog distresa kod mladih i sredovečnih bolesnika

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## Abstract

**Background/Aim.** Diabetes mellitus (DM) represents a significant and enduring health concern and, due to various complications arising from inadequate management, leads to disability and mortality. The aim of this study was to examine the impact of the family-engaged multidisciplinary collaborative care (FEC) model on the management of type 2 DM (T2DM) in young and middle-aged patients, considering the presence of DM distress. **Methods.** The study included 98 patients aged 18 to 59 diagnosed with T2DM and experiencing DM distress. The patients were admitted to the Department of Endocrinology of The First People's Hospital of Jingzhou, in Hubei province, China, between February and December 2023. Using the random number table method, the patients were randomly assigned to either the intervention group (IG) or control group (CG), each consisting of 49 patients. While both groups received standard care, IG additionally received FEC. We assessed and compared glycated hemoglobin (HbA1c) levels, Diabetes Distress Scale (DDS) scores, Summary of Diabetes Self-care Activities (SDSCA) scores, and body mass index (BMI) between the two groups before the intervention and three months after. **Results.** Three months post-intervention, IG exhibited lower HbA1c levels ($6.02 \pm 0.63$ vs. $6.81 \pm 0.85$) and DDS scores ($25.27 \pm 2.70$ vs. $34.24 \pm 4.46$) while demonstrating higher SDSCA scores ($30.69 \pm 1.91$ vs. $25.03 \pm 2.13$) compared to CG. Additionally, the BMI of patients in IG measured $23.83 \pm 2.51$ kg/m², which, compared to the BMI of CG ($25.64 \pm 3.68$ kg/m²), was statistically significant ($p < 0.05$). **Conclusion.** The FEC model demonstrated efficacy in lowering HbA1c levels and BMI, mitigating DM distress, and enhancing self-care capabilities among young and middle-aged patients with T2DM experiencing DM-related distress.

**Key words:**
**adult; diabetes mellitus, type 2; family; outcome assessment, health care; stress, physiological.**

## Apstrakt

**Uvod/Cilj.** Dijabetes melitus (DM) predstavlja značajan i trajan zdravstveni problem koji zbog raznih komplikacija koje nastaju usled neadekvatne kontrole stanja, dovodi do invaliditeta i mortaliteta. Cilj rada bio je da se ispita uticaj multidisciplinarnog modela nege koji uključuje saradnju porodice (MNSP) na lečenje tipa 2DM (T2DM) kod mladih i sredovečnih bolesnika, uzimajući u obzir prisustvo DM distresa. **Metode.** Istraživanjem je obuhvaćeno 98 bolesnika uzrasta od 18 do 59 godina sa dijagnozom T2DM i koji su ispoljavali distres povezan sa DM . Bolesnici su primljeni na Odeljenje za endokrinologiju, Prve narodne bolnice Jingdžou, u provinciji Hubei, Kina, između februara i decembra 2023. godine. Korišćenjem metode tabele slučajnih brojeva, bolesnici su nasumično raspoređeni ili u

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interventnu grupu (IG) ili u kontrolnu grupu (KG), a u svakoj je bilo po 49 bolesnika. Dok su ispitanici obe grupe primili standardnu negu, ispitanici IG su dodatno dobili i MNSP. Procenjivani su i upoređivani nivoi glikoziliranog hemoglobina (HbA1c), *Diabetes Distress Scale* (DDS) skorovi, *Summary of Diabetes Self-care Activities* (SDSCA) skorovi i indeks telesne mase (ITM) između dve grupe, pre intervencije i tri meseca kasnije. **Rezultati.** Tri meseca posle intervencije, kod IG su utvrđeni niži nivoi HbA1c (6,02 ± 0,63 vs. 6,81 ± 0,85) i DDS skorovi (25,27 ± 2,70 vs. 34,24 ± 4,46), a viši SDSCA skorovi (30,69 ± 1,91 vs. 25,03 ± 2,13) u poređenju sa KG. Dodatno, ITM bolesnika u IG iznosio je 23,83 ± 2,51 kg/m², što je u odnosu na ITM bolesnika u KG (25,64 ± 3,68 kg/m²) bilo statistički značajno ($p < 0,05$). **Zaključak.** Multidisciplinarni MNSP je pokazao efikasnost u snižavanju nivoa HbA1c i ITM, ublažavanju distres tegoba povezanih sa DM i poboljšanju sposobnosti samopomoći kod mladih i sredovečnih bolesnika sa T2DM i prisutnim distres tegobama povezanim sa DM.

**Ključne reči:**
odrasle osobe; dijabetes melitus, tip 2; porodica; zdravstvena zaštita, procena ishoda; stres.

## Introduction

Diabetes mellitus (DM) is a metabolic disorder characterized by persistent hyperglycemia resulting from a combination of genetic and environmental factors. It represents a prevalent and enduring health concern, marked by various complications arising from inadequate management and substantial rates of disability and mortality [1]. In the 21st century, DM has emerged as a prominent global health challenge [2, 3]. A recent survey conducted by the International Diabetes Federation (IDF) revealed that approximately 537 million adults (aged 20–79 years) worldwide experienced DM in 2021, with the prevalence expected to escalate to 643 million by 2030 and 783 million by 2045 [1]. The IDF Diabetes Atlas, 10th edition [4], reported that in 2021, nearly half of adults with DM were unaware of their condition, and a significant portion (46.2%) of global deaths attributed to DM occurred in individuals under the age of 60 [5].

China, in particular, has witnessed a surge in DM subjects, claiming the title of the country with the highest number of patients, reaching 141 million adults in 2021 and projected to rise to 174 million by 2045 [1]. Type 2 DM (T2DM) constitutes over 90% of all DM subjects [6]. The Guidelines for the Prevention and Treatment of Type 2 Diabetes Mellitus in China (2020 Edition), issued by the Chinese Diabetes Section of the Chinese Medical Association, reported a prevalence of 11.2% among adults aged 18 years and above [7]. Notably, the onset of T2DM is concentrated in adults aged 40–59 years, with 59% of subjects aged 18–59 years [8, 9]. The prevalence of DM is escalating rapidly among young and middle-aged (YMA) adults, and the age of onset is decreasing [10, 11].

Another study conducted in China highlighted that DM distress affects 42.50−77.23% of patients with DM, with a 90.82% prevalence in young patients with T2DM. Among them, 57.14% exhibited severe DM and 33.67% had moderate DM. Younger patients are particularly susceptible to DM-related psychological distress [12–14]. Despite being integral to families and society [15], YMA patients with T2DM receive less attention compared to their older counterparts [16]. This demographic faces lower awareness and treatment adherence levels due to work and educational commitments [17]. Furthermore, a lack of understanding about DM prevention and treatment may lead some middle-aged patients with T2DM to self-discontinue medication upon achieving satisfactory blood glucose (BG) control or due to personal preferences [18], resulting in disease progression. Although self-care is a common strategy for managing chronic diseases, YMA patients with T2DM exhibit poorer adherence to diet, medication, and exercise compared to their older counterparts [19–24].

Given the distinctive characteristics of YMA patients with T2DM, including their substantial numbers, elevated mortality rates, susceptibility to DM distress, low diagnosis rates, poor self-care practices, and limited attention, the aim of this study was to assess the health outcomes of this demographic through the implementation of a family-engaged multidisciplinary collaborative care (FEC) model.

## Methods

### Participants

This research study included patients aged between 18 and 59 years diagnosed with T2DM and experiencing DM distress. The patients participated in this study voluntarily and without any compensation. At the initial outpatient screening, all participants had poorly controlled glycated hemoglobin A1c (HbA1c) levels $\geq 6.5\%$ and a Diabetes Distress Scale (DDS) score $\geq 3$. Due to their condition, these patients agreed to be hospitalized. The study recruited both newly diagnosed patients and those with a previous diagnosis of T2DM who had consistently poorly controlled glycemic levels. The participants were hospitalized in the Department of Endocrinology at The First People's Hospital of Jingzhou in Jingzhou City, Hubei province, China, from February to December 2023. The sample size was determined using the formula for two sample means: $n_1 = n_2 2\left[\frac{(\mu_\alpha + \mu_\beta)}{\delta/\sigma}\right]^2 + \frac{1}{4}\mu_\alpha^2$. Employing a two-sided test with a significance level of $\alpha = 0.05$ and $\beta = 0.1$ corresponded to u0.05/2 = 1.96 and u0.01 = 1.282, which aligns with previous reports [24], where δ was 8.4 and σ was 11.89. Consequently, each group required a minimum of 42 subjects, and given a dropout rate of 20%, 50 subjects were eventually included in each group. Random codes were generated using the random number table method, assigned to groups, and placed in sequentially marked black sealed envelopes. Patients who met the inclusion and exclusion criteria randomly selected envelopes, which, based

on the assigned number, administered them to the control group (CG) or the intervention group (IG) (50 subjects *per* group). One case from the IG was lost to follow-up during the intervention (the patient was referred to another hospital), and one case from the CG was lost to follow-up at the third month of follow-up (the patient refused the follow-up due to distance). Consequently, 49 patients in each group completed the study.

The inclusion criteria for patients were as follows: individuals diagnosed with T2DM as *per* the diagnostic criteria outlined in the Guidelines for the Prevention and Treatment of Type 2 Diabetes Mellitus in China (2020 Edition) [25], with the additional requirement of family involvement; individuals aged between 18 and 59 years [26]; individuals with a DDS score $\geq 3$ [27]; individuals who willingly volunteered for participation in the study and provided informed consent by signing a consent form; individuals proficient in using WeChat.

Exclusion criteria for participants were as follows: individuals experiencing severe or acute complications of DM; individuals with severe primary diseases affecting the heart, brain, or kidneys; individuals with a history of psychiatric disorders or cognitive deficits, such as dementia; individuals facing language communication barriers.

The study received an approval from the Ethics Committee of the The First People's Hospital of Jingzhou (No. KY202348, from March 16, 2023). General information between the two groups was comparable with no statistically significant difference ($p > 0.05$) (Table 1).

**Table 1**

**General information on the two groups of patients with type 2 diabetes mellitus**

| Parameter | Intervention group (n = 49) | Control group (n = 49) | $t/\chi^2$ | $p$ |
|---|---|---|---|---|
| Sex | | | 0.049[a] | 0.825 |
|     male | 34 (69.4) | 35 (71.4) | | |
|     female | 15 (30.6) | 14 (28.6) | | |
| Age (years) | 44.18 ± 9.462 | 44.78 ± 7.531 | 0.135[b] | 0.733 |
| BMI | | | 0.228[a] | 1.000 |
|     < 18.5 | 2 (4.1) | 2 (4.1) | | |
|     18.5~23.9 | 15 (30.6) | 15 (30.6) | | |
|     24~27.9 | 18 (36.7) | 17 (34.7) | | |
|     ≥ 28 | 14 (28.6) | 15 (30.6) | | |
| Marital status | | | 0.3462[b] | 0.841 |
|     married | 40 (81.6) | 41 (83.7) | | |
|     single | 7 (14.3) | 7 (14.3) | | |
|     divorced | 2 (4.1) | 1 (2.0) | | |
| Education level | | | 0.460[a] | 0.928 |
|     primary school and below | 6 (12.2) | 7 (14.3) | | |
|     junior high school | 19 (38.8) | 18 (36.7) | | |
|     senior high school and middle special school | 8 (16.3) | 10 (20.4) | | |
|     college degree or above | 16 (32.7) | 14 (28.6) | | |
| Monthly income, RMB | | | 0.313[a] | 1.000 |
|     1,000~1,999 | 3 (6.1) | 4 (8.2) | | |
|     2,000~2,999 | 5 (10.2) | 5 (10.2) | | |
|     3,000~3,999 | 12 (24.5) | 11 (22.4) | | |
|     ≥ 4,000 | 29 (59.2) | 29 (59.2) | | |
| Medical payment methods | | | 1.181[a] | 0.881 |
|     out-of-pocket payment | 0 (0) | 1 (2.0) | | |
|     new rural cooperative medical system | 17 (34.7) | 16 (32.7) | | |
|     employee insurance | 15 (30.6) | 15 (30.6) | | |
|     commercial insurance | 4 (8.2) | 5 (10.2) | | |
|     medical insurance for residents | 13 (26.5) | 12 (24.5) | | |
| Living style | | | 1.054[a] | 0.788 |
|     with children | 7 (14.3) | 7 (14.3) | | |
|     with spouse | 36 (73.5) | 38 (77.6) | | |
|     alone | 3 (6.1) | 3 (6.1) | | |
|     other | 3 (6.1) | 1 (2.0) | | |
| Occupation | | | 0.541[a] | 0.991 |
|     farmer | 10 (20.4) | 11 (22.4) | | |
|     worker | 12 (24.5) | 10 (20.4) | | |
|     public servant/institution staff/formal work | 14 (28.6) | 15 (30.6) | | |
|     unemployed | 4 (8.2) | 4 (8.2) | | |
|     retired | 3 (6.1) | 2 (4.1) | | |
|     other | 6 (12.2) | 7 (14.3) | | |

**BMI – body mass index; RMB – Renminbi (Chinese yuan).**
**Values are given as numbers (percentages) or mean ± standard deviation.**
**Note: a – $\chi^2$ value; b – *t*-value.**

*Control group*

Patients received standard care during their hospital stay and underwent regular follow-ups *via* telephone and WeChat after discharge. The specific interventions implemented are presented in Table 2 (see Supplementary Material for the full content of standard care).

*Intervention group – Establishment of a collaborative care team*

The collaborative care team comprised eight members: an endocrinologist, a psychologist, a therapist, a die-titian, an endocrinology nurse practitioner, two DM-specialized nurses, and a graduate nursing student. With the active participation of patients' family members, the multidisciplinary nursing team comprehensively evaluated patients, identified issues, set goals, and formulated personalized, holistic nursing plans. They determined the implementation methods, provided ongoing evaluations of the interventions, and offered discharge guidance and feedback. In contrast, patients in the CG received routine clinical nursing, which included regular monitoring of BG, medication guidance, and health education. The specific responsibilities of each team member are outlined in Table 3.

**Table 2**

**Specific interventions for the control group**

| Care in the hospital | | | Care after discharge | | |
|---|---|---|---|---|---|
| Day 1 from admission | Day 2 from admission to 1 day prior to discharge | Day of discharge | Telephone follow-up | WeChat follow-up | Regular follow-up |
| Instruction was imparted on self-care practices for T2DM, encompassing scientifically tailored dietary measures, judicious exercise routines, appropriate medication adherence, hypoglycemia prevention, and psychological counseling. | Specialist nurses provided personalized instructions based on the specific medical conditions of individual patients. | Specialized nurses delivered centralized instruction on blood glucose monitoring and insulin injection using instructional models within the education room. Subsequently, patients were invited to participate in the "TT WeChat group chat for young and middle-aged individuals" for ongoing follow-up. | The physical and mental statuses of the patients were comprehensively assessed, and they were instructed to adhere to the prescribed medication regimen, including responding to any inquiries posed by the medical professionals. | In the "WeChat group chat for young and middle-aged individuals with TT" information regarding TT was disseminated through textual content, images, videos, and audio files, accompanied by interactive question-and-answer sessions. | During the third month of the intervention, the patient underwent a telephonic notification for the purpose of the follow-up. |

**T2DM – type 2 diabetes mellitus**; **TT – textual toolbar.**

**Table 3**

**The duties of each member of the family-involved multidisciplinary collaborative care team**

| Members | Duties |
|---|---|
| Endocrinology nurse practitioner | Assume the role of team leader, supervise the development of diverse management programs, team training and assessment initiatives, and workflow processes. Conduct regular meetings to consolidate, rectify, and control the ongoing tasks. |
| Graduate nursing student | Design intervention programs, conduct statistical data analysis, and compose research papers. Formulate general information questionnaires, and select survey scales. |
| Specialist | Tasked with diagnosing, treating, and modifying treatment regimens based on evolving patient conditions. Offer guidance on pertinent medical information. |
| Specialist nurse | Offer guidance on professional nursing knowledge and skills. Engage in the distribution and retrieval of questionnaires. Contribute to the comprehensive care of the research program. |
| Psychologist | Evaluate the psychological condition of patients. Deliver expert psychological counseling. |
| Dietitian | Compute BMI for patients. Evaluate the nutritional status of patients and offer appropriate nutritional counseling. |
| Therapist | Evaluate the patient's motor status. Prescribe exercises tailored to patients with DM, based on their BMI. |

**Table 3 (continued)**

| Members | Duties |
|---|---|
| Families of patients | Oversee patients in the timely completion of daily tasks. Offer emotional support and encouragement to patients. Engage in standard care practices and health education for individuals with DM. Administer nutritional support to patients based on the guidance of a registered dietitian. Aid patients in mobility and exercise routines. |
| Patients | Fulfill the program requirements with both qualitative and quantitative excellence. Adhere diligently to prescribed dietary, exercise, and blood glucose monitoring regimens. Collaborate with the psychologist to actively engage in the conscious adjustment of psychological well-being. |

**BMI – body mass index; DM – diabetes mellitus.**

*Intervention group – Implementation program*

IG patients were administered care through the FEC model rooted in conventional practices. The FEC approach encompassed comprehensive assessment, problem identification, goal establishment, formulation of an individualized and holistic care plan, selection of implementation methods, evaluation of effects, and provision of discharge guidance and feedback (Table 4).

*Evaluation indicators*

The assessment criteria encompassed DDS scores, Summary of Diabetes Self-care Activities (SDSCA) scores, body mass index (BMI) values, and HbA1c levels. Developed by Polonsky et al. [13] in 2005, the DDS comprises 17 entries across four dimensions, utilizing a 6-point Likert scale to assign scores ranging from 1 (no problem) to 6 (a serious problem) for each item, resulting in a total score of 102. A higher score indicates increased distress. The Cronbach's coefficient for the DDS was calculated as 0.951, affirming its internal consistency.

SDSCA, devised by Toobert et al. [28] for assessing self-care behavior in diabetes patients over the preceding seven days, has undergone several revisions. This scale encompasses 11 scoring entries categorized into five dimensions: diet (overall and specific), exercise, BG monitoring, foot care, and medication. Each entry is scored on a scale from 0 to 7, culminating in a total score ranging from 0 to 77 points. Li et al. [29] evaluated the reliability and validity of the SDSCA, reporting Cronbach's $\alpha$ of 0.84 for the entire scale and Cronbach's $\alpha$ values ranging from 0.71 to 0.93 for each subscale, confirming the scale's overall reliability and validity.

*Statistical analysis*

The data analysis was performed using SPSS 19.0 software. Descriptive statistics for qualitative data included counts and percentages, with between-group comparisons conducted using the Chi-squared test. Quantitative data exhibiting normal distribution are presented as mean ± standard deviation. Between-group comparisons for quantitative data were carried out using the two independent samples $t$-tests, while intragroup comparisons utilized the paired $t$-test. Statistical significance was determined at a threshold of $p < 0.05$.

**Results**

*Analysis of HbA1c levels before and after the interventions conducted in two distinct groups*

Following the interventions, statistically significant reductions in HbA1c levels were observed in both groups, with a $p < 0.001$. The $t$-values for the CG and IG were 0.422 ($p = 0.674$) and -5.249 ($p < 0.001$), respectively. These values suggest that the reduction in HbA1c levels was notably more pronounced in the IG post-intervention, highlighting the efficacy of the intervention in this group (Table 5).

*Comparisons of DDS scores conducted before and after interventions in both study groups*

Following the intervention in the IG, there was a substantial decrease in DDS scores ($p < 0.001$). In contrast, the CG exhibited a comparatively lower reduction in DDS scores after the intervention, with mean differences (MD) changing from 47.71 ± 3.33 to 34.24 ± 4.46 ($t = 16.951$, $p < 0.001$). The $t$-values for the IG and CG were -0.316 and -12.07 ($p < 0.001$), respectively. These results indicate significant enhancements in diabetes distress among patients in the IG, while the CG showed less improvement (Table 6).

*Comparisons of pre- and post-intervention BMI variations within the two study groups*

BMI disparity between the two groups reached statistical significance following the interventions ($p < 0.001$). Conversely, there was no notable alteration in the BMI of patients within the CG post-intervention ($p > 0.05$) (Table 7).

*A comparative analysis of the SDSCA scores before and after interventions in the two groups*

Following the interventions, a significant reduction in the SDSCA scores was observed in the IG ($p < 0.001$), while the CG experienced a relatively modest decrease (MD = 25.03 ± 2.13). The CG exhibited a modest enhancement in the SDSCA score (MD = 25.03 ± 2.13). In contrast, the IG demonstrated a substantial rise in the total SDSCA score, progressing from an initial MD of 15.07 ± 4.50 to a final MD of 30.69 ± 1.91 ($t = 13.864$, $p < 0.001$). These findings indicate a notable enhancement in patients' self-care ability within the IG (Table 8).

**Table 4**

**Specific interventions for the intervention group**

| Usual care in the hospital | | | Care after discharge | | |
|---|---|---|---|---|---|
| Days 1−2 from admission | Day 3 from admission to 1 day prior to discharge | Day of discharge | Telephone follow-up | WeChat follow-up | Regular follow-up |
| Apart from standard care, the following elements are incorporated:<br><br>Extend invitations to patients and their families to participate in the "Collaborative Care Communication Group," providing an introduction to the components of the family-engaged multidisciplinary collaborative care model.<br><br>Thoroughly evaluate patients' conditions and formulate individualized care plans for each patient.<br><br>Collaboratively devise a professional intervention plan for patients' conditions involving all team members. | Within the interdisciplinary team, each professional undertakes individualized interventions to address patient issues, employing a hybrid approach that integrates both online and offline methodologies. Offline nurses instruct patients and their families on the preparation of a DM diet in accordance with the dietitian's plan, utilizing the "Boohee Dietitian" app. The therapist educates patients on appropriate exercise regimens, while the psychologist conducts bi-weekly psychological interventions. Families play a vital role in supporting and overseeing patients to ensure timely completion of tasks. Additionally, the online "Collaborative Care Communication Group" sporadically disseminates videos featuring psychological interventions and healthy exercises for individuals with T2DM. The specialized nurse transmits the intervention outcomes of patients to the "Collaborative Care Communication Group," where team members formulate a new plan informed by the outcomes of their deliberations. | The specialist nurses provide individualized guidance on monitoring blood glucose levels and administering insulin through one-on-one sessions. Patients' families undergo assessment through a test paper, and patients scoring > 80 are deemed satisfactory. Individuals failing to meet the examination criteria receive personalized guidance focused on areas of insufficient comprehension and mastery, incorporating the examination results. Subsequently, they undergo reevaluation until achieving qualification. | Understand the physical and mental status of patients, advise them to adhere to prescribed medication regimens as directed by physicians, and address any inquiries they may have. | Enhance the understanding of DM by participating in the "Collaborative Care Communication Group," addressing inquiries and resolving uncertainties related to health knowledge.<br><br>Gather the findings from the self-monitoring blood glucose card weekly *via* the "Collaborative Care Communication Group," ensuring submission by 9:00 p.m. each Sunday.<br><br>Foster patient engagement by encouraging the sharing of their results and experiences within the group. | During the third month of the intervention, patients were contacted *via* phone for a scheduled follow-up, and a lecture took place in the endocrinology department's demonstration classroom. The lecture focused on elucidating the significance and appropriate methodologies for engaging T2DM patients and their families in the effective management of DM. |

**T2DM – type 2 diabetes mellitus (DM).**

**Table 5**

**Comparisons of HbA1c levels before and after interventions in the intervention and control groups**

| Parameter | HbA1c (%) | | $t$ | $p$ |
|---|---|---|---|---|
| | before interventions | three months after interventions | | |
| Intervention group (n = 49) | 11.00 ± 1.92 | 6.02 ± 0.63 | 17.24 | < 0.001 |
| Control group (n = 49) | 10.84 ± 1.79 | 6.81 ± 0.85 | 14.24 | < 0.001 |
| $t$ | 0.422 | -5.249 | | |
| $p$ | 0.674 | < 0.001 | | |

**HbA1c – glycated hemoglobin.**
**Values are given as mean ± standard deviation.**

**Table 6**

**Comparisons of DDS scores before and after interventions in the two groups**

| Parameter | DDS | | $t$ | $p$ |
|---|---|---|---|---|
| | before interventions | three months after interventions | | |
| Intervention group (n = 49) | 47.51 ± 3.06 | 25.27 ± 2.70 | 38.195 | < 0.001 |
| Control group (n = 49) | 47.71 ± 3.33 | 34.24 ± 4.46 | 16.951 | < 0.001 |
| $t$ | -0.316 | -12.07 | | |
| $p$ | 0.753 | < 0.001 | | |

**DDS – diabetes distress scale.**
**Values are given as mean ± standard deviation.**

**Table 7**

**Comparisons of BMI before and after interventions in the two groups**

| Parameter | BMI (kg/m$^2$) | | $t$ | $p$ |
|---|---|---|---|---|
| | before interventions | three months after interventions | | |
| Intervention group (n = 49) | 26.13 ± 4.12 | 23.83 ± 2.51 | 3.346 | 0.001 |
| Control group (n = 49) | 25.81 ± 3.97 | 25.64 ± 3.68 | 0.213 | 0.832 |
| $t$ | 0.397 | -2.86 | | |
| $p$ | 0.692 | 0.005 | | |

**BMI – body mass index.**
**Values are given as mean ± standard deviation.**

**Table 8**

**Comparisons of SDSCA scores before and after interventions in the two groups**

| Parameter | IG (n = 49) | CG (n = 49) | $t/z$ | $p$ |
|---|---|---|---|---|
| Diet management | | | | |
| before | 2.36 ± 0.70 | 5.78 ± 0.81 | 0.116 | 0.908 |
| after | 2.35 ± 0.70 | 4.84 ± 0.91 | 5.398 | <0.001 |
| $t/z$ | 0.212 | -15.209 | | |
| $p$ | < 0.001 | < 0.001 | | |
| Exercise management | | | | |
| before | 2.45 ± 0.83 | 2.40 ± 0.84 | 0.302 | 0.763 |
| after | 5.64 ± 0.83 | 3.80 ± 0.99 | 9.99 | < 0.001 |
| $t/z$ | 0.870 | -7.512 | | |
| $p$ | < 0.001 | < 0.001 | | |
| Blood glucose monitoring | | | | |
| before | 3 (1.4) | 3 (2.4) | -0.87 | 0.930 |
| after | 6 (5.7) | 4 (4.5) | -5.169 | < 0.001 |
| $t/z$ | -7.754 | -5.533 | | |
| $p$ | < 0.001 | < 0.001 | | |
| Foot care | | | | |
| before | 1 (1.4) | 2 (1.4) | -0.080 | 0.936 |
| after | 7 (6.7) | 5 (4.6) | -5.548 | < 0.001 |
| $t/z$ | -7.905 | -6.509 | | |
| $p$ | < 0.001 | < 0.001 | | |

**Table 8 (continued)**

| Parameter | IG (n = 49) | CG (n = 49) | *t/z* | *p* |
|---|---|---|---|---|
| Medication | | | | |
| before | 7 (1.7) | 7 (3.7) | -0.211 | 0.833 |
| after | 7 (7.7) | 7 (6.7) | -3.279 | < 0.001 |
| *t/z* | -4.644 | -3.094 | | |
| *p* | < 0.001 | 0.002 | | |
| Total score | | | | |
| before | 15.07 ± 4.50 | 15.01 ± 3.94 | 0.69 | 0.945 |
| after | 30.69 ± 1.91 | 25.03 ± 2.13 | 13.864 | < 0.001 |
| *t/z* | -22.369 | -15.661 | | |
| *p* | < 0.001 | < 0.001 | | |

**SDSCA – Summary of Diabetes Self-care Activities; IG – intervention group; CG – control group.**
**Values are given as mean ± standard deviation or numbers (percentages).**

## Discussion

T2DM is a lifelong metabolic disorder characterized by persistent hyperglycemia, with no definitive cure [30], necessitating continuous and lifelong therapeutic interventions. Managing this condition in China, a country facing a significant diabetes burden, is particularly challenging. These challenges are compounded by the diverse family dynamics of patients, many of whom belong to families with varying socioeconomic statuses, responsibilities for both elderly care and child-rearing, and differing educational backgrounds. In the IG, the educational levels of patients and their family members ranged from primary school to advanced degrees, making health education a complex and time-consuming task. Given these differences, ensuring that patients and their families understand and apply the necessary health education further complicates diabetes management and increases the overall cost of care.

The imperative lies in identifying novel, effective, and feasible strategies to enhance diabetes care and therapeutic outcomes. The FEC model addresses nursing assessment issues, employing information technology for case-specific analysis. This model strategically directs healthcare resources toward bolstering comprehensive physical and psychological care, ensuring continuous support from admission to discharge for YMA patients with T2DM experiencing DM distress.

Through the coordinated efforts, distinct roles, collective wisdom, and synergistic strengths of multidisciplinary medical staff and family involvement, this model establishes a comprehensive and standardized long-term care mechanism for hospitals catering to the needs of YMA patients with T2DM with DM distress. Our study revealed a significant disparity in HbA1c levels, DDS scores, BMI values, and SDSCA scores between the CG and IG three months post-intervention ($p < 0.001$), aligning with the findings of Abdulrhim et al. [3], highlighting the positive impact of the FCE model on patient satisfaction, quality of life (QoL), and health status.

Furthermore, additional research indicated a correlation between DM distress and poor DM control [31]. Consequently, the FEC model emerges as clinically crucial in the compre-

hensive care of YMA patients with T2DM experiencing DM distress.

As reported [32], DM distress is higher and more common in younger patients than in older patients, which may be related to the family, social, and work responsibilities of younger patients. Owens-Gary et al. [33] stated that DM distress increased the risk of death, poor disease management, DM-related complications, and poor QoL and that FEC could improve DM distress in patients with DM. Likewise, our findings indicated significantly lower DDS scores in the FEC model group compared to the CG ($p < 0.001$). This underscores the heightened effectiveness of the FEC model in alleviating the condition of YMA patients with T2DM experiencing DM distress. It has been reported that family support and involvement in adult DM care elevate the motivation and self-efficacy of patients in managing DM [34]. Jiang et al. [35] found through a Mate analysis that family-engaged education was beneficial to BG control in T2DM patients. Meanwhile, another study indicated that disease management with family involvement ameliorated the anxiety and depression of patients and enhanced their QoL [36]. Accordingly, it is vital to actively encourage the patients' families to participate in managing chronic diseases and to work together with patients and medical staff to combat the disease.

In recent years, there has been a notable increase in the prevalence of DM, coinciding with a rise in the incidence of obesity and overweight conditions. The risk of developing T2DM shows a twofold increase with a weight gain of 5–8 kg and a fourfold increase with a weight gain of 20 kg or more [37]. Obesity has emerged as a significant factor contributing to the onset of T2DM [38]. According to survey data, 41.0% of patients with DM in China are overweight, and 24.3% are classified as obese [39].

Fisher et al. [40] highlighted that rates of DM distress tend to be higher in specific demographic groups, including women, relatively young adults, insulin-using patients, those with poorer BG control, individuals with a high BMI, those with a prolonged duration of DM, and those with significant comorbidities associated with DM.

Consequently, it can be inferred that the effective management of BMI is crucial for individuals with DM. In our study, the FEC model demonstrated a more significant im-

pact on BMI compared to the conventional care approach ($p < 0.001$). Conversely, BMI in the CG exhibited no statistically significant difference before and after the intervention ($p > 0.05$).

As the prevalence of DM continues to rise, self-care has emerged as a pivotal element in DM management [41]. In this study, we focused on a self-care intervention tailored for YMA patients with T2DM experiencing DM distress. Following a comprehensive regimen encompassing dietary adjustments, exercise, medication adherence, BG monitoring, and psychological support, patients exhibited a significant elevation in their SDSCA scores ($p < 0.001$). The multifaceted nature of the intervention underscores the intricate landscape of DM management, intensifying the challenges associated with self-care.

In concordance with our findings, the study by Nielsen et al. [42] demonstrated a greater impact of interventions on T2DM compared to type 1 DM (T1DM). This was associated with a reduction in HbA1C levels among patients with T2DM, aligning with outcomes observed in our study. The variance in intervention outcomes suggests that the effectiveness of self-care strategies may differ between T2DM and T1DM populations, emphasizing the importance of tailored approaches.

The crucial link between self-care and QoL in patients with DM is well-established [43], underscoring the necessity of maintaining sustained self-care practices. The results of our study affirm that educating patients on proper dietary habits and incorporating exercise into their routines can positively influence unhealthy lifestyle patterns, thereby enhancing their QoL and exerting favorable control over their condition. Consequently, healthcare professionals bear the responsibility of imparting relevant information and skills to empower patients in their self-care journey.

In this study, potential biases may exist due to the varied family backgrounds and socioeconomic statuses of the patients, as well as differences in self-care experience between newly diagnosed and previously diagnosed DM patients. In future research, efforts will be made to better control these potential influencing factors by targeting larger and more diverse samples and conducting long-term follow-ups to assess the durability of the intervention's benefits. However, a notable limitation of this study is the relatively brief intervention duration (three months). Consequently, future research endeavors should consider extending the intervention period to provide more robust insights.

**Conclusion**

The family-engaged multidisciplinary collaborative care model proves advantageous for comprehensive care and both the physical and mental development of young and middle-aged patients with type 2 diabetes mellitus experiencing diabetes distress. Furthermore, it facilitates the implementation of ongoing care, enhances the quality of care, optimizes healthcare resources, and improves the self-care capabilities of patients.

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## Supplement

### Standard care for the control group

### Stage 1 – In hospital

*Day 1 of admission*

1. Determine patients based on inclusion and exclusion criteria.

2. Collect baseline data, including general information, the Diabetes Distress Scale, and the Self-Management Behavior Scale. Measure body weight and height, calculate BMI, and perform blood tests for glycated hemoglobin (HbA1c) levels.

3. Conduct type 2 diabetes mellitus (T2DM) self-management knowledge guidance:

Emotional guidance:

- Communicate with the patient to understand their current emotional state and provide methods for emotional relief, such as talking, listening to music, or jogging.

Exercise guidance:

- Moderate aerobic exercise – aerobic exercises (walking, swimming, cycling) can improve body sensitivity and help lower blood sugar levels.

- Patients can exercise three times a week, for about 30 minutes.

- Regular exercise timing – maintaining a consistent daily exercise schedule can help stabilize blood sugar levels and improve overall health.

- The best time for exercise is one hour after meals. Carry candy, biscuits, and identification cards while exercising.

- The appropriate exercise intensity is determined by the formula: post-exercise heart rate (beats/min) = 170 - age.

Scientific dietary guidance:

- Control the intake of staple foods like rice and wheat carbohydrates.

- Choose low-glycemic index (GI) foods – low-GI foods cause a slower increase in blood sugar levels, which helps maintain stable blood sugar control. For instance, choose whole wheat bread or brown rice instead of high-GI foods.

- Balanced diet – reasonably combine staple foods, proteins, and vegetables to ensure adequate nutrition in each meal and control overall intake to maintain an appropriate weight.

- Recommend cooking methods such as stewing, steaming, or boiling.

- Avoid high-fat foods – limit excessive intake of saturated and trans fats, and choose foods rich in healthy fats, like vegetable oils and fish.

- Control alcohol consumption – alcohol affects blood sugar regulation, so diabetic patients should limit alcohol intake and avoid drinking on an empty stomach.

Medication guidance:

- Eemphasize the importance of following the doctor's prescription and explain diabetes-related medications' effects, usage methods, and side effects.

Prevention, identification, and management of hypoglycemia:

- Diabetic patients should use medication according to the doctor's recommendations, undergo regular check-ups, and maintain good communication with their doctor to ensure proper disease management and control.

- Regularly monitor blood sugar levels and carry sugary foods (candy, snacks) when going out. Seek immediate medical attention at a nearby hospital if hypoglycemia occurs.

Implementation method: Data collection at the nurse's station, bedside education.

Time: Data collection takes 10–20 minutes, and knowledge guidance takes 30–45 minutes.

Implementers: Two specialized diabetes mellitus (DM) nurses and one graduate student conduct data collection and knowledge guidance.

*From the second day of admission to the first day before discharge*

Content: Improve relevant auxiliary examinations and provide corresponding guidance based on the results.

Implementation method: Bedside one-on-one.

Implementers: Two specialized DM nurses.

*Discharge day*

1. Invite discharged patients to join the WeChat group for "Young and Middle-aged DM Patient-Doctor Communication" for follow-up and health education after discharge.

2. Blood glucose monitoring and insulin injection guidance.

Blood glucose monitoring:

- Use a fixed blood glucose meter to monitor blood glucose levels before each meal and before bedtime daily to adjust diet and insulin dosage.
- Monitor blood glucose levels if symptoms such as dizziness or cold sweat occur to determine if hypoglycemia is happening.

Insulin injection:

- Ensure the injection site is clean and avoid injecting in the same spot consecutively.
- Preferred injection sites: the abdomen—2 inches around the navel to the iliac crest (avoiding the navel area); the buttocks—muscles in the outer upper quadrant of the buttocks; the outer front thigh; the outer arm area.
- Regularly change needles to prevent cross-infection and pause for 10 seconds after injection.
- Follow medical advice on medication and obtain the doctor's consent before altering the dosage.

Time: 20–30 minutes.

Implementation method: One-on-one bedside guidance.

Implementers: Two DM specialist nurses.

## Stage 2 – Outside the hospital

*Telephone follow-up*

Content: Monitor the patient's blood sugar control at home, see whether any complications have occurred, and address any questions or concerns.

Frequency: Once a week, 10–20 minutes each time.

Implementers: One graduate student and two DM specialist nurses.

*WeChat follow-up*

Content: Through the "Middle-aged and Young DM WeChat Group," disseminate health knowledge in text, image, video, or audio form, address questions and concerns, and inform about the follow-up appointment times.

Frequency: Once a week, 10–20 minutes each time.

Implementers: One graduate student and two DM specialist nurses.

*Regular outpatient visits*

Content: One week after discharge and in the third month after the intervention, call the patient to inform them about a follow-up appointment at the outpatient clinic. In the third month after the intervention, collect the patient's Diabetes Distress Scale, Self-Management Behavior Scale, Patient Care Satisfaction Survey, and body mass index (BMI) data at the clinic. Additionally, perform blood sampling and monitor BMI.

Implementation method: One week after discharge, visit the hospital to collect random blood glucose samples and adjust the treatment plan based on the patient's condition. In the third month after the intervention, collect data one-on-one at the outpatient clinic, perform blood sampling, and recheck HbA1c. Adjust the treatment plan accordingly.

Duration: Data collection takes 10–20 minutes, and blood sampling takes 2–5 minutes.

Implementers: One graduate student and two DM specialist nurses.